State of California
The Resources Agency
Department of Fish and Game

# RECOVERY STRATEGY FOR CALIFORNIA COHO SALMON

Report to the California Fish and Game Commission

Prepared by
The California Department of Fish and Game

**Species Recovery Plan Report 2003-1**

August 2003

# Threats 3

The severity of the decline in the numbers of coho salmon and the number of extirpated populations increases as one moves closer to the historical southern limit of the species' range, suggesting that these environments are less able to support coho salmon populations than in the past. Freshwater habitat loss and degradation have been identified as leading factors in the decline of anadromous salmonids in California, including the coho salmon. Timber harvest activities, especially past and present road construction, have had deleterious effects on coho salmon habitat. Diversion of water for agricultural, domestic, and other purposes, and dams that block access to former habitat, have resulted in further reduction of habitat. Water quality in streams historically inhabited by coho salmon has degraded substantially, as evidenced by the number of north- and central-coast streams that have been placed on the list of impaired water bodies, pursuant to section 303 of the Clean Water Act (CWA).



## 3.1 CLIMATIC VARIATION

California experiences wide variation in climatic and hydrologic conditions. Various climatic phenomena including severe storms, drought, seasonal cycles, El Niño and La Niña events, decadal events, and regime shifts can alter the physical, chemical, and biological aquatic environment (Parrish and Tegner 2001). These changes can, in turn, play a major role in the life history, productivity, and persistence of coho salmon populations. Coho salmon evolved with, and have persisted in the face of, extreme variability in habitat conditions caused by these natural phenomena. However, catastrophic conditions combined with low population numbers, habitat fragmentation, impacts of human activities, and habitat degradation or loss can cause an unrecoverable decline of a given population or species (Moyle et al. 1995).

### 3.1.1 DROUGHT

In California, coho salmon populations exist in many coastal streams where stream closures occur due to sandbar formation at their mouths, created through coastal wave action and low summer flows. Coho salmon are able to identify their natal stream by the seepage of fresh water entering the ocean through the bars, but they are unable to enter the streams until fall or winter rains increase flows sufficiently to breach the sand bars. Shapovalov and Taft (1954) found that streams south of San Francisco may not be passable until as late as March. When this happens, a large portion of the run may enter the stream over a short period. Up to 70% of the total returning spawning population may enter the stream from the ocean within a few days (Sandercock 1991). During prolonged droughts, sandbars may never open in a given season. When that happens, spawners are unable to enter those streams (Anderson 1995). Reduced flows can reduce habitat quantity and result in increased water temperature, causing increased heat stress to fish and thermal barriers to migration.

### 3.1.2 FLOODING

High flows associated with floods can result in complete loss of eggs and alevins as they are scoured from the gravel or buried in sediment (Sandercock 1991; NMFS 1998). Juveniles and smolts can be stranded on the floodplain, washed downstream to poor habitat such as isolated side channels and off-channel pools, or washed out to sea prematurely. Peak flows can induce adults to move into isolated channels and pools or prevent their migration through excessive water velocities.

Streams can be drastically modified by erosion and sedimentation in large flood flows almost to the extent of causing uniformity in the stream bed (Spence et al. 1996). After major floods, streams can take years to recover pre-flood equilibrium conditions. Flooding is generally not as devastating to salmon in morphologically complex streams, because protection is afforded to the fish by the natural in-stream structures such as LWD and boulders, stream channel features such as pools, riffles, and side channels and an established riparian area (Spence et al. 1996).

Flooding does, however, have beneficial effects: cleaning and scouring of gravels; transporting sediment to the flood plain; moving and rearranging LWD; recharging flood plain aquifers (Spence et al. 1996); allowing salmonids greater access to a wider range of food sources (Pert 1993); and maintaining the active channel.

### 3.1.3 OCEAN CONDITIONS

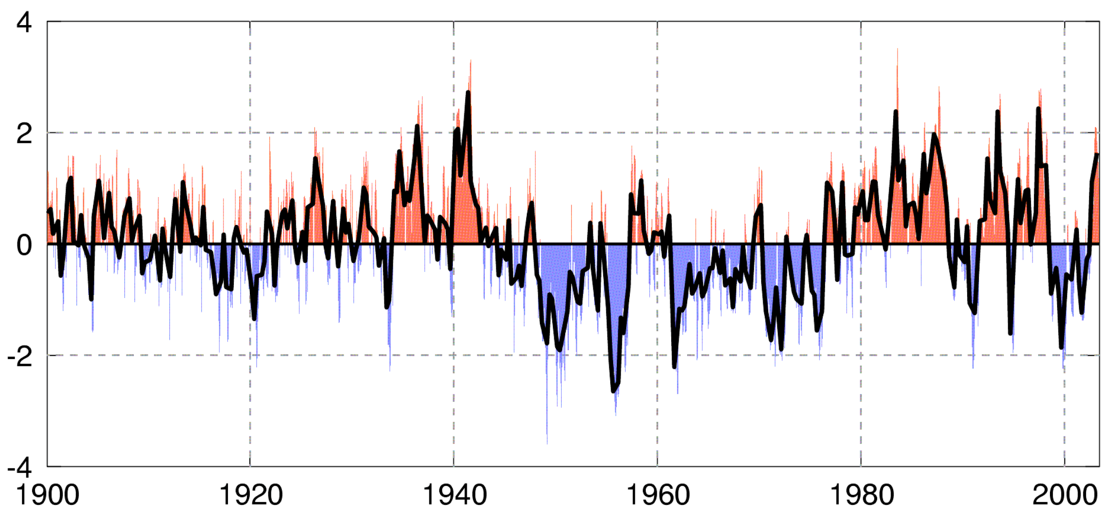
Changing ocean conditions, extreme climatic conditions, and natural variation in ocean conditions can strongly impact Pacific salmon populations. However, salmon populations have not, until the past century, experienced these conditions in conjunction with the widespread degradation of their spawning, rearing, and overwintering habitat caused by human related activities (Brown et al. 1994; Anderson 1995).

Periodic changes in Pacific currents, winds, and upwelling regimes have had major impacts on the primary and secondary productivity of the northeast Pacific Ocean (Brown et al. 1994; Mantua et al. 1997). These oceanic events, described as El Niño/Southern Oscillation (ENSO) and Pacific (Inter) Decadal Oscillation (PDO), and depending on phase, are associated with both declines and increases in ocean survival and decreases and increases in size of coho and Chinook salmon (Johnson 1988; Spence et al. 1996; Tschaplinski 1999; Cole 2000; Ryding and Skalski 1999; Koslow et al. 2002). ENSO events are of relatively short duration (6-18 months) with their primary influence in the tropics and secondary expression in the North Pacific/North American sector. In contrast, PDO events are most visible in the North Pacific and typically cycle over periods of about 50 years; within a PDO cycle there may be short-lived reversals of conditions (Mantua 2003). Figure 3-1 summarizes monthly PDO indices developed by the University of Washington; negative values indicate cool PDO periods that are generally favorable for coho salmon populations in California.

Marine conditions have several ramifications that must be considered in planning for coho salmon recovery and the interpretation of monitoring results. The cyclic nature of marine productivity, as outlined by Lawson (1993), can mask the reproductive decline of a salmonid population. The conceptual model he presents combines the effects of oceanic cycles and freshwater habitat degradation. As the freshwater habitat degrades, the salmon populations do not decline in an immediate and linear fashion. Instead, due to the long-term cycles of productivity in the marine environment, the downward trend in freshwater productivity can be masked by higher escapement due to more favorable oceanic conditions. These trends must be considered when assessing the success of coho salmon recovery efforts.



FIGURE 3-1: Monthly values for the PDO index: Jan 1900—Apr 2003




Source: http://tao.atmos.washington.edu/pdo/

## 3.2 DISEASE

Coho salmon are susceptible to an array of bacterial, viral, parasitic, and fungal diseases found in many salmonids of the Pacific Northwest. Symptomatic conditions appear when fish are stressed by high water temperatures, crowding, environmental contaminants, or a decreased oxygen supply (Warren 1991). Diseases affect various life stages differently. Diseases and disease agents in California that can cause significant losses in adult salmonids include: bacterial kidney disease (*Renibacterium salmoninarum*), furunculosis (*Aeromonas salmonicida*), columnaris (*Flexibacter columnaris*), Pseudomonas/Aeromonas, infection and ichthyopthirius or “ich” (*Ichthyophthirius multifiliis*) (William Cox pers. comm.). The diseases that are known to cause significant losses in juvenile salmonids are furunculosis, columnaris, coldwater disease (*Flexibacter psychrophilis*), pseudomonas and aeromonas, ichthyopthirius, nanophyetes, and ceratamyxosis (*Ceratamyxa shasta*) (William Cox pers. comm.).

The introduction of disease by hatchery fish into wild stocks is an increasing concern, but the degree of risk and seriousness of the problem are little known (Brown et al. 1994).

## 3.3 PREDATION

Predation occurs during all life stages of the coho salmon and it is accommodated by a healthy population; however it can be detrimental to those populations with low numbers or poor habitat conditions (Anderson 1995).

### 3.3.1 FRESHWATER PREDATION

Predators in the freshwater environment, such as invertebrates, fish, and birds, reduce the survival rate of eggs and alevins (Sandercock 1991). Some native fishes known to consume coho salmon are: sculpin (*Cottus spp.*), Sacramento pikeminnow (*Ptychocheilus grandis*), steelhead rainbow trout (*Oncorhynchus mykiss*), coastal cutthroat trout (*O. clarki clarki*), and other coho salmon (Shapovalov and Taft 1954; Sandercock 1991; Anderson 1995). Non-native fishes such as Sacramento pikeminnow *(Ptychocheilus grandis*), smallmouth bass *(Micropterus dolomieu*), and channel catfish *(Ictalurus punctatus*) can consume significant numbers of juvenile salmon if the conditions are favorable for them (NMFS 1998). Striped bass *(Morone saxatilis*) can also be a significant predator of juvenile salmonids, and has been observed in the Russian River system. However, there is no indication that they have had a significant impact on con salmon. Avian predators of juvenile salmonids include dipper (*Cinclus mexicanis*), gulls (*Larus spp.*), belted kingfisher (*Megaceryle alcyon*), herons (*Ardea spp*.), common merganser *(Mergus merganser*), and osprey (*Pandion haliaetus*) (Sandercock 1991; Spence et al. 1996). Among mammalian predators that can impact salmonid populations, mink (*Mustela vison*) and otter (*Lutra canadensis*) can take significant numbers of the overwintering coho salmon juveniles and migrating smolts, although this is dependent upon conditions favorable to predators and the availability of other prey (Sandercock 1991).

### 3.3.2 MARINE PREDATION

The relative impacts of marine predation on anadromous salmonids are not well understood, though documentation of predation from certain species is available. NMFS (1998) noted that several studies have indicated that piscivorous predators may control salmonid abundance and survival. Beamish et al. (1992) documented predation of hatchery-reared chinook and coho salmon by spiny dogfish *(Squalus acanthia*s). Pacific hake (*Merluccius productus*) and pollock (*Theragra chalcogramma*) are known to consume salmon smolts (Holtby et al. 1990). Marine sculpins also consume juvenile salmonids, although salmonids are not a major part of their diet.

There are many known avian predators of juvenile salmonids in the estuarine and marine environments. Some of these include belted kingfisher, gulls, grebes (*Podicipedidae*); and loons (*Gavia* spp.), herons, egrets, bitterns (*Ardeidae*); cormorants (*Phalacrocorax* spp.), terns (*Sterna* spp.), mergansers (*Mergus* spp.), pelicans (*Pelecanus* spp.), auklets, murres, murrelets, guillemots, and puffins (*Alcidae*); and sooty shearwater (*Puffinus grisens*) (Emmett and Schiewe 1997; NMFS 1998). Bald eagles (*Haliaeetus leucocephalus*) and osprey are predators of adult salmonids (Emmett and Schiewe 1997). It is important to note that these predators are opportunistic feeders, preying upon the most abundant and easiest to catch.

In most cases, salmonids appear to be a minor component of the diet of marine mammals (Scheffer and Sperry 1931; Jameson and Kenyon 1977; Graybill 1981; Brown and Mate 1983; Roffe and Mate 1984; Hanson 1993; Botkin et al. 1995; Goley and Gemmer 2000; Williamson and Hillemeier 2001a, 2001b). The principal food sources of marine mammals include lampreys (Jameson and Kenyon 1977; Roffe and Mate 1984; Hanson 1993), benthic and epibenthic species (Brown and Mate 1983; Hanson 1993), and flatfish (Scheffer and Sperry 1931; Graybill 1981; Hanson 1993; Goley and Gemmer 2000; Williamson and Hillemeier 2001a, 2001b). Although salmonids appear to make up a relatively minor component of the diet of seals and sea lions, this does not indicate conclusively that pinniped predation is not significant. Predation may significantly influence salmonid abundance in populations when other prey are absent and physical habitat conditions lead to the concentration of adult and juvenile salmonids in small areas (Cooper and Johnson 1992).

## 3.4 HATCHERIES

A large body of evidence supports the conclusion that artificial propagation can be detrimental to natural and hatchery salmonid populations (Steward and Bjornn 1990; Hindar et al. 1991; Waples 1991b; Campton 1995; Flagg et al. 2000). Several published studies have found that hatchery stocks are generally less productive in the wild than locally adapted natural stocks, and that transplanted stocks are also less productive than locally adapted natural ones (Leider et al. 1990; Waples 1991b; Meffe 1992; Fleming and Gross 1993; Reisenbichler and Rubin 1999).

Although no direct connection can be made because specific data are lacking, stock transfers from various sources from within and from outside California have been implicated by several authors as a factor that might have contributed to the low diversity and weak population genetic divergence observed in California coho salmon stocks (Brown and Moyle 1991; Bartley et al. 1992; Weitkamp et al. 1995; NMFS 2001a). Prolonged hatchery stocking in a particular stream should not be used by itself as documentation of extinction of a distinct wild population. Wild coho salmon stocks can persist in the presence of extensive hatchery stocking.

Hatcheries may have contributed to declines of coho salmon in California, although to what degree is unknown. Currently, their potential to do harm is limited by decreased hatchery production and modern management policy. Hatcheries in California have dramatically reduced their production of coho salmon, limited outplanting, and stopped virtually all stock transfers in recent years. Therefore, current impacts of hatchery fish on remaining natural stocks are significantly less than in the past.

## 3.5 GENETIC DIVERSITY

An understanding of the existing range and pattern of genetic diversity is essential to effective recovery planning. Section 2.5 reviews the available population genetics information for coho salmon, including patterns of genetic variation that will be useful first approximations for delimiting populations.

Maintenance of genetic diversity is crucially important to the recovery of depleted stocks because genetically diverse taxa:

- Have a potential for greater overall abundance because different populations can exploit different habitats and resources,
- Exhibit enhanced long-term stability due to spread risk and redundancy in the face of unpredictable catastrophes (e.g., dramatic rapid fluctuation of climatic or ocean conditions), and
- Contain a broad range of raw material that allows adaptation and increases the probability of persistence in the face of long-term environmental change (McElhany et al. 2000; Levin and Shiewe 2001).

Numerous literature sources have expressed concerns about loss of genetic diversity in California coho salmon populations (CDFG 200; Hedgecock et al. 2002; NMFS 2001; Weitkamp et al. 1995; Brown et al. 1994; Brown and Moyle 1991). Coho salmon status reviews (CDFG 2002; NMFS 2001; Weitkamp et al. 1995; Brown et al. 1994; Brown and Moyle 1991) have consistently characterized many California coho salmon populations as small and fragmented, with missing brood years in some places. Some of the threats to genetic diversity that were identified in these reviews are shown in Table 3-1. These include: small population size effects, inappropriate levels of migration or straying, negative hatchery-natural interactions, and missing brood years. Any recovery actions should take these possible factors into account.

Table 3-1: Identified concerns about maintenance of existing genetic diversity and possible causes of reduction of genetic diversity in California coho salmon

| FACTOR | RESULTS | EFFECT ON RECOVERY POTENTIAL |
|---|---|---|
| Few breeding individuals in each population | Reduced $N_e$<br>Inbreeding depression<br>Increased rate of genetic drift<br>Allee Effect | Loss of within-population genetic diversity<br>Reduced fitness<br>Reduced adaptive potential<br>Reduced evolutionary potential<br>Inability to find mates<br>Reduced productivity<br>High vulnerability to catastrophic events and rapid environmental change |
| Migration and straying (both more and less than natural rates) | Impaired metapopulation structure<br>Inappropriately high migration rate among populations<br>Outbreeding depression | Reduced connectivity among populations<br>Loss of between-population genetic diversity (Homogenization of stocks)<br>Loss of adaptive complexes<br>Reduced fitness<br>Reduced productivity |
| Hatcheries | Domestication of broodstock<br>Negative natural/hatchery interactions | Loss of adaptive complexes<br>Genetic swamping<br>Reduced fitness of all run components (HO, NO, and HO+NO)<br>Replacement of well adapted natural runs with poorly adapted hatchery runs<br>Inappropriate levels of straying<br>Masking of declines in natural run size |
| Missing brood years and local extinction | Reduced $N_b$, $N_e$<br>Loss of potential migrants<br>Change in population age structure<br>Incomplete brood-year cycles<br>Impaired metapopulation structure | Loss of genetic diversity components<br>Reduction of potential for gene flow among brood years<br>Loss of adaptive potential |

Sources: CDFG 2002, Hedgecock et al. 2002, NMFS 2001, Weitkamp et al. 1995, Brown et al. 1994, Brown and Moyle 1991.

Loss of genetic variation can mean loss of alleles, loss of heterozygosity, or changes in allele frequencies. All of these have the potential to reduce fitness, and can be detrimental to the character and persistence of breeding populations. The risks associated with loss of genetic diversity have been explored in a number of published works including Waples (1991b), Currens and Busack (1995), Busack and Currens (1995), Campton (1995), Grant (1997), and Utter (1998). Loss of variation has been implicated as a factor limiting evolutionary potential (Frankham et al. 1999), and can affect the potential range of response to pathogens (O'Brien and Everman 1989).

Small populations can experience genetic diversity losses through inbreeding and genetic drift. Loss of variation due to inbreeding depression has been reported as a factor that may increase the probability of local extinction (Saccheri et al. 1998). When new populations arise from small numbers of individuals, founder effects can also cause geographically close populations to be different from one another. These effects are countered by migration among populations (straying), mutation, and selection.

Introgressive hybridization can reduce genetic diversity and fitness of genetically different stocks. Straying, artificially high levels of gene flow, and/or inappropriate choice of broodstock for hatchery supplementation may cause locally adapted populations to be more similar to one another with concomitant loss of adaptative complexes, reduced fitness, lowered productivity, and reduction of recovery potential. Even if hybridization effects only become evident in the second generation, long-term recovery may be impeded. It is important to draw a distinction between total genetic diversity and adaptive genetic diversity. The ability of a population to respond to change can be negatively affected by unique but maladaptive genes that nonetheless add to total genetic diversity.

Much of the discussion in the literature regarding loss of diversity has been in the context of impacts associated with hatchery management and practice, and interactions of hatchery fish with natural fish. These impacts include loss of fitness due to domestication and artificial selection that can occur in hatcheries and a variety of other possible negative effects (see CDFG 2002 for a review). In the course of recovery planning, it is important to avoid hatchery impacts of all kinds on recovering stocks, even as we consider the valid use of hatcheries to affect recovery.

Many of the causes of genetic diversity loss are related to decreases in population size and associated decreases in effective population size (Ne) and number of breeders (Nb). Because per generation loss of genetic diversity is related to the effective population size of the spawner population, several authors have proposed Ne thresholds that can be used as guidelines in evaluating the severity of potential genetic diversity reductions. The upper portion of Table 3-2 shows some effective population size guidelines from the literature. The lower portion of Table 3-2 shows estimates of the number of breeders per generation and the number of breeders per year that would theoretically be needed to maintain genetic diversity in populations of California coho salmon.

Because salmon populations are usually connected by some small amount of gene flow, and gene flow between populations is a contributor to overall genetic variation, smaller than predicted effective sizes might be sufficient to maintain diversity. Because of this, these guidelines may be more appropriate for evaluating the potential for genetic diversity loss in isolated runs that do not experience immigration from other places. Estimates from two of the studies shown in Table 3-2 (Franklin 1980 and Lande 1995) were based on study of a single species, the fruit fly *Drosophila melanogaster*, and might not be generally applicable to salmon (McElhaney et al. 2000). Therefore, these guidelines should not be used as hard targets for recovery unless they are supported on a case-by-case basis. They can be useful for roughly estimating the potential for diversity loss due to small population size in the absence of specific data. For example, a population with consistent returns of 50 spawners per year might be judged large enough to avoid inbreeding depression, but we would be less confident that a population of this size could maintain adaptive potential over the long term.



TABLE 3-2: Guidelines for number of breeders per generation and number of breeders per year needed to maintain genetic diversity in populations of California coho salmon

Values of $N_e$ or $N_b$ needed to maintain genetic variation:

- Franklin (1980): avoidance of inbreeding depression: $N_e$ = 50
- Waples (1990): maintain short term genetic variation [based on p(loss of rare alleles)]: $N_b$ /year = 100
- Franklin (1980) and Lande and Barrowclaw (1987): avoidance of long-term loss of genetic variation: $N_e$ = 500
- Lynch (1990), maintain genetic variation in a population: $N_e$ = 1,000
- Lande (1995), maintain potentially adaptive genetic variation: $N_e$ = 5,000

| $N_e$ /$N_t$=<br>$N_e$ min | 0.1<br>$N_b$ per generation | 0.1<br>$N_b$ per year | 0.33<br>$N_b$ per generation | 0.33<br>$N_b$ per year |
|---|---|---|---|---|
| 50 | 500 | 167 | 152 | 51 |
| 100 | 1,000 | 333 | 303 | 101 |
| 500 | 5,000 | ***1,667*** | 1,515 | 505 |
| 1,000 | 10,000 | 3,333 | 3,030 | 1,010 |
| 5,000 | 50,000 | ***16,667*** | 15,152 | 5,051 |

Notes:
$N_e$ is effective population size, $N_b$ is number of breeders, and $N_t$ is the total census population size. Estimates of $N_e$ /$N_t$ for pacific salmon range from 0.1 to 0.33. An average generation length of three years is used in the calculations. Values in bold italics were identified in CDFG (2002) as precautionary targets for maintenance of genetic variation in coho salmon populations.

## 3.6 LAND USE

A variety of actions and land uses have degraded freshwater and estuarine habitat, created barriers to salmon passage, or degraded coho salmon habitat in other ways. This section describes some of these problems.

### 3.6.1 FORESTRY ACTIVITIES

Forestry practices have been shown to impact several freshwater habitat components important to anadromous salmonids in general, and coho salmon specifically. These impacts include: increased maximum and average summer water temperatures, decreased winter water temperature, and increased daily temperature fluctuations; increased sedimentation; loss of LWD; decreased dissolved oxygen (DO) concentrations; increased instream organic matter; and decreased stream bank stability (Salo and Cundy 1987; Meehan 1991; Moring et al. 1994; Murphy 1995; Monschke 1996). Even when some habitat conditions return to pre-timber-harvest levels, fish populations do not always recover, which may be due to other habitat conditions remaining sub-standard or having been permanently altered (Moring et al. 1994). Logged areas are further affected and aggravated by natural incidents (e.g., blow-downs, landslides) and by human activity subsequent to logging, all of which may result in negative cumulative effects to coho salmon and their habitat.

Identifying the relationships between forestry practices and habitat impacts is complicated for several reasons. First, there is a long history of timber harvesting, and some effects, such as sedimentation and slope instability, continue long after harvesting has occurred. These alterations are referred to as "legacy" effects, and recovery may take many decades (Murphy 1995). Legacy effects are a factor along the north coast of California (Monschke 1996). Second, there have been many technological and management changes in timber harvest, and it is difficult to differentiate legacy effects from recent or current effects. Third, the salmonid habitat elements affected by timber harvest are themselves intimately inter-related. The amount and size frequency distribution of LWD, water temperature, near-stream vegetation, sediment transport and deposition, landsliding, stream flow and supply, and turbidity are all linked to one another.

During the approximately 150-year history of timber harvest in coastal northern California, harvest practices have changed dramatically, primarily due to changes in technology and decreasing availability of larger or higher quality logs. Where historical harvest and milling were close to waterways, modern trucks and tractors have enabled harvesting to occur in a wider variety of areas within a watershed. Logs were once primarily transported by river and are now transported by trucks along specially constructed roads. Logs used to be removed from the forest by mules and railroad, and these mechanisms have been replaced by tractors and cabling networks.

Current forestry activities that affect coho salmon habitat include: construction and maintenance of roads and stream crossings; tree felling; moving felled trees to log landings; removal of streamside vegetation; site preparation; and post-harvest broadcast burning in harvest units near watercourses. Table 3-3 describes forestry practices, changes to the landscape, and the potential effects on salmonid habitat conditions. As described in the discussion of legacy effects, there are on-going impacts to coho salmon habitat from historic timber operations.

The Department's conclusion is that historical forestry practices impacted watersheds inhabited by northern California coho salmon, and that current activities (e.g., road construction, use, and maintenance; activity near streams and on unstable slopes; removal of sources of future LWD) still affect important habitat elements essential to every life-stage of coho salmon that inhabit coastal streams and rivers.

### 3.6.2 WATER DIVERSIONS AND FISH SCREENS

A substantial amount of coho salmon habitat has been lost or degraded as a result of water diversions and groundwater extraction. The nature of diversions varies enormously, from major water developments which can alter the entire hydrologic regime in a river, to small domestic diversions which may only have a localized impact during the summer low flow period. In some streams the cumulative effect of multiple small legal diversions may be severe. Illegal diversions are also believed to be a problem in some streams within the range of coho salmon.

Diversions are subject to regulation by the State Water Resources Control Board through the appropriative water rights process, and by the Department of Fish and Game under FGC§1600 et seq. (which requires an agreement with the Department for any substantial flow diversion), FGC§2080 et seq. (CESA take authorization), and FGC§5937 (which requires sufficient water below a dam to maintain fish in good condition). NOAA Fisheries has authority under ESA to regulate the take of coho salmon at diversions. Hydroelectric diversions, such as those on the Klamath and the Eel rivers are also subject to regulation by the Federal Energy Regulatory Commission (FERC).

In some watersheds, the demand for water has already exceeded the available supply and water rights have been allocated though a court adjudication. These adjudications usually have not considered coho salmon habitat needs at a level that could be considered protective under CESA. The use of wells adjacent to streams is also a significant

TABLE 3-3: Forestry activities and potential effects to stream environment, salmonid habitat, and salmonid biology

| Forest Practice | Potential Effects to: Stream Environment | Salmonid Habitat | Salmonid Biology |
|---|---|---|---|
| Timber harvest in the riparian zone | increased incident solar radiation | increased stream temperature, light levels, and primary production | decreased growth efficiency; increased susceptibility to disease; increased food productivity; changes in growth rate and age at smolting |
| | decreased supply of LWD | decreased cover, storage of gravel and organic debris, and protection from high flows; loss of pool habitat and hydraulic and overall habitat complexity | decreased carrying capacity, spawning gravel, food production, and winter survival; increased susceptibility to predation; loss of species diversity |
| | increased, short-term input of LWD | increase in number of pools and habitat complexity; creation of debris jams | increased carrying capacity for juveniles and winter survival; barrier to migration and spawning and rearing habitat |
| | increased influx of slash | increased oxygen demand, organic matter, food, and cover | decreased spawning success; short-term increase in growth |
| | stream bank erosion | reduced cover and stream depth | increased carrying capacity for fry; decreased carrying capacity for older juveniles; increased predation |
| | | increased instream fine sediment; reduced food supply | reduced spawning success; slower growth rates for juveniles |
| Timber harvest on upslope areas | altered stream flow | temporary increase in summer stream flow | temporary increase in survival of juveniles |
| | | increased severity of peak flows during storm season; bedload shifting | increased egg mortality |
| Timber harvest on upslope areas and road construction and use | increased erosion and mass wasting | increased instream fine sediment; reduced food supply | reduced spawning success, growth and carrying capacity; increased mortality of eggs and alevins; decreased winter hiding space and side-stream habitat |
| | | increased instream coarse sediment | increased *or* decreased carrying capacity |
| | | increased debris torrents; decreased cover in torrent tracks; increased debris jams | blockage to migration of juveniles and spawning adults; decreased survival in torrent tracks |
| | increased nutrient runoff | increased primary and secondary production | increased growth rate and summer carrying capacity |
| | stream crossings | barrier in stream channel; increased sediment input | blockage or restriction to migration; reduced spawning success, carrying capacity and growth; increased winter mortality |
| Scarification and slash burning | increased nutrient runoff | increased primary and secondary production | increased growth rate and summer carrying capacity |
| | increased input of fine organic and inorganic sediment | increased sedimentation in spawning gravels and production areas; temporary increase in oxygen demand | decreased spawning success; increased mortality of eggs and alevins |

Source: Adapted from Hicks et al. 1991

and growing issue in some parts of the coho salmon range. Extraction of flow from such wells often directly affects the adjacent stream, but is often not subject to same level of regulatory control as diversion of surface flow.

Losses of coho salmon result from a wide range of conditions related to unscreened water diversions and substandard fish screens. Primary concerns and considerations for fish at diversions that are unscreened or equipped with poorly functioning screens are:

a. Delay of downstream migration and reduced overall survival of downstream migrants;
b. Entrainment of juvenile coho salmon into the diversion;
c. Impingement of juvenile coho salmon on the screen because of high approach velocities or low sweeping velocities;
d. Predator holding areas created by localized hydraulic effects of the fish screen and related facilities;
e. Entrapment of juvenile coho salmon in eddies or other hydraulic anomalies where predation can occur;
f. Elevated predation levels due to concentrating juveniles at diversion structures; and
g. Disruption of normal fish schooling behavior caused by diversion operations, fish screen facilities, or channel modifications.



### 3.6.3 INSTREAM FLOWS

Depletion and storage of natural flows can drastically alter natural hydrological cycles and create significant impacts to downstream reaches by reducing the amount of flow needed to support coho salmon and their habitat. Impacts to coho salmon can include increasing juvenile and adult mortality by delaying migration because of insufficient flows, stranding fish during rapid flow fluctuations; decreased food supply because of reduced invertebrate drift, and increasing mortality due to higher water temperatures (CACSST 1988; CDFG 1991; Berggren and Filardo 1993; Reynolds et al. 1993; Chapman et al. 1994; Cramer et al. 1995;NMFS 1996). In addition to these factors, alteration of the natural hydrograph can increase deposition of fine sediments in spawning gravels, decrease recruitment of LWD and spawning gravels; it may also lead to encroachment of riparian and non-endemic vegetation into spawning and rearing areas (e.g., on the Trinity River) (CACSST 1988; FEMAT 1993; Botkin et al. 1995; NMFS 1996).

Many of the watersheds where coho salmon are present have been developed and flows have been regulated and significantly reduced compared to natural flows. Base flow necessary for coho salmon rearing during the typical May to November low flow period may be severely limited due to interactions between watershed area, climate, geology, and land use. For example, an Instream Flow Incremental Methodology (IFIM) study of lower Scott Creek, Santa Cruz County (Snider et al., 1995) found that optimum habitat conditions for juvenile steelhead and coho salmon in Scott Creek are provided at 20 cfs, and only half of the maximum habitat remains at 5 to 6 cfs. However, median flows in Scott Creek in August, September and October are 2 cfs or less (roughly 16% of maximum habitat).

A common problem in minimizing the direct and cumulative effects of diversions on instream flow is the lack of detailed data regarding minimum instream flow needs for coho salmon in a given stream. Some of the major water developments in the range of coho salmon are, or have been, the subject of extensive studies and programs aimed at evaluating and reducing the impact of those projects on coho salmon and other species. However, studies on the effects of smaller diversions are generally lacking, as are studies of overall instream flow needs in watersheds in the range of coho salmon. The owners of smaller diversions frequently lack the resources to conduct the appropriate studies to evaluate instream issues.

For small diversions (≤ 3 cfs and ≤ 200 acre-feet) in Mendocino, Sonoma, Marin and Napa counties the Department of Fish and Game and NOAA Fisheries have proposed draft guidelines that may serve as conditions for protection of salmonid habitat in lieu of results from site specific studies (CDFG/NOAA 2002), but in some cases these conditions may require substantial alteration of existing diversion and storage patterns. Current resource agency staffing and funding is generally inadequate to conduct watershed-level instream flow studies and to take the effective regulatory actions to restore flow for coho salmon habitat where it is an issue. The lack of adequate enforcement staff and problems coordinating efforts by regulatory agencies also makes consistent control of illegal diversion difficult.

### 3.6.4 ARTIFICIAL BARRIERS

Artificial structures on streams fragment aquatic ecosystems by blocking or impeding migration and altering nutrient cycling patterns, streamflows, sediment transport, channel morphology, and stream-corridor species composition. This reduces available habitat, changes habitat conditions for anadromous salmonids, and reduces native biodiversity. Instream structures have the potential to, depending on conditions, either entirely or partially block fish from accessing upstream reaches and block critical habitat necessary for survival. Barriers can be formed by:

a. Road crossings (e.g., bridges, culverts, and low-water fords);
b. Dams;
c. Flood-control structures (e.g., concrete channels);
d. Erosion control structures (riprap and energy dissipaters);
e. Canal and pipeline crossings;
f. Pits from gravel mining; and
g. Conditions that sever surface or subsurface hydrologic connections between the stream channel and adjacent wetlands.

Even if stream barriers are eventually negotiated by fish, the extra energy expended may result in their death prior to spawning or in reductions in viability of eggs and offspring. Barriers that increase the time required for migration can limit the distance adult fish are able to travel upstream before spawning, resulting in the crowding of redds in lower stream reaches and under-utilization of upstream habitat. Migrating adults and juveniles concentrated below barriers with impassable crossings are also more vulnerable to predation and illegal harvest.

Hydropower and water storage projects alter the hydrograph of downstream river reaches and can affect migration cues and physical passage conditions. Dams often block access to areas used historically by coho salmon. NMFS (1995) identified a nine dams in California that currently have no fish passage facilities to allow coho salmon access to former spawning and rearing habitats. Blocked habitat constitutes approximately 9 to 11 % of the historical range of each coho salmon ESU. Five major dams within the California portion of the SONCC ESU (Table 3-4) and four major dams within the CCC ESU (Table 3-5) block access to historical spawning and rearing areas of coho salmon. In addition to these, there are five smaller impoundments on the mainstem Russian River, and approximately 500 licensed or permitted dams on its tributaries (SEC 1996).



TABLE 3-4: Major dams within the California portion of the Southern Oregon/ Northern California Coast Coho ESU that block coho salmon from accessing historical spawning and rearing habitat

| NAME OF DAM | LOCATION | UPSTREAM HABITAT BLOCKED | PERCENT OF BASIN |
|---|---|---|---|
| Scott Dam | Eel River, approximately 169 miles upstream from the Pacific Ocean, forming Lake Pillsbury in Lake County | 36 miles | 8% (Eel River Basin) |
| Matthews Dam | Mad River, approximately 79 miles upstream from the Pacific Ocean, forming Ruth Lake in Trinity County | 2 miles | 13% (Mad River Basin) |
| Lewiston Dam | Trinity River (tributary to the lower Klamath River), approximately 112 miles upstream from the Pacific Ocean, forming Lewiston Reservoir in Trinity County | 109 miles | 24%(Trinity Basin)<br>9% (Klamath Basin |
| Dwinnel Dam | Shasta River (tributary to the upper Klamath River), approximately 214 miles upstream from the Pacific Ocean, forming Dwinnell Reservoir in Siskiyou County | 17 miles | 17% (Shasta Basin)<br>2% (Klamath basin) |
| Iron Gate Dam | Klamath River, approximately 190 miles upstream from the Pacific Ocean, forming Iron Gate Reservoir in Siskiyou County | 30 miles | 8% (Klamath basin) |

TABLE 3-5: Major dams within the Central California Coast Coho ESU that block coho salmon from accessing historical spawning and rearing habitat

| NAME OF DAM | LOCATION | UPSTREAM HABITAT BLOCKED | PERCENT OF BASIN |
|---|---|---|---|
| Peters Dam | Lagunitas Creek, approximately 14 miles upstream from the Pacific Ocean, forming Kent Lake in Marin County | 8 miles | 6% |
| Nicasio Dam | Nicasio Creek, (tributary to Lagunitas Creek), approximately 8 miles upstream from the Pacific Ocean, forming Nicasio Reservoir in Marin County | 5 miles | 10% |
| Warm Springs Dam | Dry Creek (tributary to the Russian River), approximately 45 miles upstream from the Pacific Ocean, forming Sonoma Lake in Sonoma County | 50 miles | 9% |
| Coyote Dam | Russian River, approximately 95 miles upstream from the Pacific Ocean, forming Lake Mendocino in Mendocino County | 36 miles | 7% |

### 3.6.5 GRAVEL EXTRACTION

Instream mining (the removal of sediment from the active channel) has various impacts on salmonid habitat by interrupting sediment transport and often causing channel incision and degradation (Kondolf 1993). The impacts that can result from instream mining include: direct mortality; loss of spawning habitat; noise disturbance; disruption of adult and juvenile migration and holding patterns; stranding of adults and juveniles; increases in water temperature and turbidity; degradation of juvenile rearing habitat; destruction or sedimentation of redds; increased channel instability and loss of natural channel geometry; bed coarsening; lowering of local groundwater level; and loss of LWD and riparian vegetation (Humboldt County Public Works 1992; Kondolf 1993; Jager 1994; Halligan 1997). Terrace mining (the removal of aggregate from pits isolated from the active channel) may have similar impacts on salmonids if a flood causes the channel to move into the gravel pits.

While instream gravel extraction has had direct, indirect, and cumulative impacts on salmonids in the recent past, no direct impacts to coho salmon have been documented under the current (post-1995) mining monitoring and reporting standards developed by the Department and the mining industry which were incorporated into: County Conditional Use Permits; State Mining and Reclamation Act (SMARA) required Reclamation Plans; and U.S. Army Corps of Engineer (USACE) Letters of Permission. Many rivers continue to suffer the effects of years of channel degradation from the millions of tons of aggregate removed from the systems over time (Collins and Dune 1990).

### 3.6.6 SUCTION DREDGING

Suction-dredge placer miners extract gold from the river gravels by sucking the gold-
Suction-dredge placer miners extract gold from the river gravels by sucking the gold-
bearing gravels through a nozzle (typically 6- to 8-in in diameter) into floating dredges, pumping the gravel and water mixture across a settling table where the gold concentrates by gravity, and then discharging the gravel and water back into the river. Both the pump and the sluice box are usually mounted on a floating platform, often positioned over the work area by ropes or cables secured to trees or rocks. The portion of stream bottom dredged ranges from a few small excavations to the entire wetted area in a section of the stream. Larger suction dredges have the capacity to process as much as several cubic yards of gravel from the river bottom at one time. An annual permit from the Department (under Title 14 CCR, section 228) and, in some circumstances, a Lake and Streambed Alteration Agreement (FGC §1600) is required to engage in this activity.

Dredging activities in freshwater environments can have a variety of direct impacts on the environment, including impacts on aquatic and riparian organisms (Griffith and Andrews 1981; Thomas 1985; Harvey 1986) and channel stability. Impacts can also result from the potential release of hazardous materials such as mercury into aquatic and terrestrial environments. However, there are no studies that document such dredging-related impacts on coho salmon or their habitat within the petitioned area. The restrictions currently imposed by regulations on this activity are designed to eliminate the potential for impacts to coho salmon by restricting suction dredging actions to locations and times when such activities should not impact the species.



### 3.6.7 STREAMBED ALTERATION

Streambed alteration activities such as construction of roads, navigational improvements, dams, bank stabilization structures, and channels can result in a loss of habitat complexity (Bisson et al. 1987). Effects include decreases in the range and variability of stream flow velocities and depths, and reductions in the amount of large wood, boulders, and other stream structures. Construction activities in the stream channel can cause excess sediment to fill pools. Channelization that includes paving the channel bottom, or changing the length or sinuosity of the channel, permanently alters the substrate, eliminating macroinvertebrate habitat, instream vegetation, and the gravel substrate necessary for spawning.

### 3.6.8 WATER QUALITY

Water pollution originates from point sources and non-point sources as listed in Table 3-6, and includes nutrients, biocides, metals, and metalloids. It is difficult to correlate specific pollutants with specific and direct effects on coho salmon. Mixed compounds may have different effects on the biological community of a stream than would an accumulation of the same compounds considered separately. In addition, effects vary with habitat alteration, temperature, and the concentration of dissolved materials in the surface waters (Brown and Sadler 1989). Water quality within coho salmon range is known to be affected by industrial discharges, agricultural discharges, mineral mining wastes, municipal wastewater discharge, road surface discharge, a urban stormwater discharge.

TABLE 3-6: Clean Water Act Section 303(d) impaired water bodies within the range of coho salmon in California

| WATER BODIES AND AREA AFFECTED | STRESSOR | SOURCE OF POLLUTION [J] |
|---|---|---|
| SAN FRANCISCO BAY | | |
| Carquinez Strait, 6560 acres;<br>Richardson Bay, 2560 acres | Chlordane; copper; DDT; PCBs; PCBs (dioxin-like); Diazinon; Dieldrin; dioxin compounds; exotic species; mercury; Furan compounds; nickel; selenium; high coliform count | 1, 5, 6, 7, 20, 26, 27, 28, 34, 38, 45 |
| San Francisco Bay, 172,100 acres | Chlordane; copper; DDT; Diazinon; Dieldrin; dioxin compounds; exotic species; Furan compounds; mercury; nickel; PCBs; PCBs (dioxin-like); selenium; high coliform count | 1, 5, 6, 7, 20, 26, 27, 28, 34, 36, 38, 47 |
| San Pablo Bay, 71,300 acres;<br>Suisun Bay, 25,000 acres;<br>Suisun Marsh Wetlands, 57,000 acres;<br>Suisun Slough, 10 miles | Chlordane; copper; DDT; Diazinon; Dieldrin; dioxin compounds; exotic species; Furan compounds; mercury; nickel; PCBs; PCBs (dioxin-like); selenium; high coliform count; metals | 1, 5, 6, 7, 15, 20, 26, 27, 28, 34, 36, 38, 45 |
| Tomales Bay; Calero Res.; Guadalupe Res.; Lake Herman; Merritt Lake; Alameda Cr.; Alamitos Cr.; Arroyo Corte Madera Delpresidio; Arroyo De La Laguna; Arroyo Del Valle; Arroyo Hondo; Butano Cr.; Calabazas Cr.; Corte Madera Cr.; Coyote Cr. (Marin and Santa Clara Cos); Gallinas Cr.; Guadalupe Cr.; Lagunitas Cr.; Laurel Cr.; Ledgewood Cr.; Los Gatos Cr.; Matadero Cr.; Miller Cr.; Mt. Diablo Cr.; Napa R.; Novato Cr.; Permanente Cr.; Pescadero Cr.; Petaluma R.; Pine Cr.; Pinole Cr.; Rodeo Cr.; San Antonio Cr.; San Felipe Cr.; San Francisquito Cr.; San Gregorio Cr.; San Leandro Cr.; San Lorenzo Cr.; San Mateo Cr.; San Pablo Cr.; San Rafael Cr.; Saratoga Cr.; Sonoma Cr.; Stevens Cr.; Walker Cr.; Walnut Cr.; Wildcat Cr. (Total: 8520 acres and 759 miles) | Metals; nutrients; pathogens; sedimentation/ siltation; mercury, floating material; organic enrichment/ low DO; Diazinon; salinity | 1, 4b, 10, 15, 25, 28, 38, 42, 44, 45 |

Continued

TABLE 3-6: Clean Water Act Section 303(d) impaired water bodies within the range of coho salmon in California (continued)

| WATER BODIES AND AREA AFFECTED | STRESSOR | SOURCE OF POLLUTION [J] |
|---|---|---|
| NORTH COAST | | |
| Albion River, 14 miles | Sediment | 28, 39 |
| Eel River Delta, 6350 acres | Sediment; temperature | 28, 31, 39 |
| Elk River, 88 miles | Sediment | 39 |
| Freshwater Creek, 73 miles | Sediment | 13, 16, 23, 28, 33, 34, 39 |
| Garcia River, 39 miles | Sediment; temperature | 13, 16, 23, 28, 32, 33, 34, 35, 39, 41 |
| Gualala River, 35 Miles | Sediment | 13, 16, 22, 23, 28, 33, 34, 39, 20 |
| Klamath River, 190 Miles | Nutrients, organic enrichment/low DO; temperature | 3, 11, 15, 17, 21, 26, 28 |
| Mad River, 90 miles | Sediment | 28, 36, 39 |
| Mattole River, 56 miles | Sediment; temperature | 13, 17, 28, 31, 32, 35, 39, 40 |



Under Section 303(d) of the 1972 Clean Water Act (CWA), states, territories and authorized tribes are required to develop lists of impaired waters that do not meet water quality standards, even after those responsible for point sources of pollution have installed the minimum required levels of pollution control technology. The law requires that these jurisdictions establish priority rankings for water on the lists and develop action plans, including total maximum daily load (TMDL) plans to improve water quality. Within the California range of coho salmon, there are 74 water bodies that are on the section 303(d) list of impaired water bodies (Table 3-6).

TMDLs in California are developed either by Regional Water Quality Control Boards (RWQCB) or by the U.S. Environmental Protection Agency (EPA). TMDLs developed by RWQCBs are designed as Basin Plan amendments and must include implementation provisions. TMDLs developed by USEPA typically contain the total load and load allocations required by Section 303(d), but do not contain comprehensive implementation provisions. It is the responsibility of the RWQCBs to develop implementation programs for TMDLs established by the USEPA and during that process, it has often been necessary for the RWQCBs to reevaluate, and sometimes change, the USEPA requirements.

### 3.6.9 AGRICULTURAL IMPACTS

Agricultural practices affect aquatic and riparian areas through non-point source pollution, since these areas eventually receive sediments, fertilizers, pesticides, and wastes from associated agricultural lands. Sediment is the most common type of non-point source pollution from agricultural lands (Knutson and Naef 1997). According to Terrell and Perfetti (1989), erosion of crop lands accounts for 40 to 50% of the sediment in United States waterways. Storm runoff erodes the topsoil from open agricultural areas, and irrigation water from standard agricultural practices also carries significant amounts of sediment to the stream environment. According to Terrell and Perfetti (1989), two types of irrigation systems, sheet flow and rill, cause the greatest amount of surface erosion, while drip irrigation and piped laterals produce the least. Irrigation often uses water that is drawn from a stream, lake, pond, or the ground. Pumping from the water table reduces its level, decreasing flow to and in the river. The ability of a stream to diminish the effects of irrigation waste discharged decreases proportionally with reductions in stream flow.

Small coastal streams often rely on springs to maintain flows through the summer months, but the flow of these springs is often diminished by pumping from the aquifers that supply them. Many streams that once flowed year-round no longer do so, because of recent increases in hillside agricultural land conversion and reduction in local groundwater levels. The conversion of uplands from forest or grasslands to agriculture increases erosion and ground water use (CDFG 2001c). In February 2000, Sonoma County adopted a vineyard ordinance to control sedimentation caused by vineyard erosion (Merenlender et al. 2000). The ordinance identified three levels of vineyards and seven types of highly erosive soils, imposing corresponding requirements (CDFG 2001c).

Animal wastes carried by runoff can contaminate water sources through the addition of oxygen-depleting organic matter (Knutson and Naef 1997). Runoff from concentrated fecal sources can change water quality, causing lethal conditions for fish. As the biochemical oxygen demand increases, dissolved oxygen decreases, and ammonia is released, causing additional changes that are stressful to fish.

Grazing can affect riparian characteristics and associated aquatic systems, such as vegetative cover, soil stability, bank and channel structure, instream structure, and water quality and quantity. Behnke and Zarn (1976) and Armour et al. (1991) indicate that overgrazing is one of the major contributing factors in the decline of Pacific Northwest salmon. Trampling may compact soils, decreasing water infiltration and increasing runoff. However, light trampling can break up surface soils that have become impervious, and allow for greater water absorption; but this also makes the soil more susceptible to erosion (Spence et al. 1996). According to Knutson and Naef (1997), some of the ways that poor grazing practices can impact fish and wildlife include:

a. Destruction of riparian vegetation;
b. Reduction or elimination of regeneration of woody vegetation;
c. Changes to plant species composition in favor of non-riparian species;
d. Loss of protective vegetation and associated bank stability and structure;
e. Soil compaction;
f. Increase of stream bank erosion, causing stream channel widening, shallowing, trenching, or braiding;
g. Reduction in the ability of riparian areas to trap and filter sediments and pollutants;
h. Increase in stream temperatures due to loss of cover;
i. Increase in the magnitudes of high and low flows;
j. Lowering of the water table, and associated loss of riparian vegetation; and
k. Loss of nutrient inputs, especially invertebrate food sources, to stream.

### 3.6.10 URBANIZATION

Humans have traditionally settled near sources of water such as streams, lakes, and bays. Though the effects of timber, livestock, and agriculture can be destructive, there is usually a chance for recovery of the landscape. In urban areas, recovery is unlikely, because once the natural vegetation is gone and the stream and riparian habitats are modified, the changes are usually permanent (Booth 1991; Spence et al. 1996). Booth (1991) indicates that urbanized watersheds may increase peak flows associated with storm and flood events by as much as five times. Areas within the range of coho salmon where large-scale urban development has taken place include Arcata-Eureka, Fortuna, Willits, Ukiah, Santa Rosa, and the San Francisco Bay Area.



### 3.6.11 FISHING

Retention of coho salmon has been prohibited in ocean commercial fisheries south of Cape Falcon, Oregon since the beginning of the 1993 season. From Cape Falcon to Horse Mountain, California, coho salmon retention has been prohibited in ocean recreational fisheries since the 1994 season, and starting May 1995, the prohibition was extended to include sport fisheries south of Horse Mountain. California's inland waters have been explicitly closed by regulation to coho salmon retention since 1998.

Coho salmon are taken incidentally in fisheries directed toward other salmon species. When regulations prohibit the retention of coho salmon, the majority of released fish survive. However, if large enough numbers are hooked, substantial mortality can be incurred.

The Klamath basin's Native American tribes (Yurok, Hoopa, and Karuk) currently operate the only existing sanctioned coho salmon fishery. Both the Yurok and Hoopa Valley tribes have federally recognized fishery rights in the basin, and tribal subsistence, ceremonial, and minor commercial fisheries operate under the regulatory authority of each tribe. Each tribe determines the extent of fishing opportunities that will be provided its tribal members based on estimates of preseason abundance. Data for this review are only available for the Yurok tribe's harvest for subsistence and ceremonial fisheries within the tribe's reservation on the lower Klamath River (Weitchpec downstream to the ocean); these fisheries have been monitored since 1992. Harvest has ranged from 27 to 1,168 fish caught annually, and based on estimates of upstream escapement (in-river spawners and hatchery returns), is thought to amount to an average harvest rate of 4.4% for the period (Dave Hillemeier pers. comm.).

### 3.6.12 ILLEGAL HARVEST

Illegal harvest can have an impact on populations of fishes in certain areas, although this depends on intensity, frequency and species of fish taken. The Wildlife Protection staff of the Department indicates that illegal harvest of both juvenile and adult coho salmon does occur, although most of the illegal take is due to anglers mistaking coho salmon for another species. Most of the violations involving the illegal take of adult coho salmon occur in the offshore sport fishery. Illegal harvest in inland waters is mostly opportunistic, meaning poachers will spear, net, gaff or snag whatever salmonid happens to be in the stream (Tom Belt pers. comm.).